DURATION OF RAINFALL AT BALTIMORE, MD.[1]

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For many years the Weather Bureau has kept records of the duration of bright sunshine at the various stations, so that this feature of climate may be easily set forth in numerical data, or in charts, for the whole United States. We know the average number of hours the sun shines unobscured and the percentage of the possible amount received. These are interesting and important climatic data.

But information as to the number of hours rain falls is very scarce. We have beginnings and endings of precipitation for many years, and from these records it is quite possible to compile data showing how many hours per day, month, and year precipitation occurs. As yet, however, very little of this work has been done. It is hoped that what has been done with the sunshine records throughout the country may be done with the rainfall records.

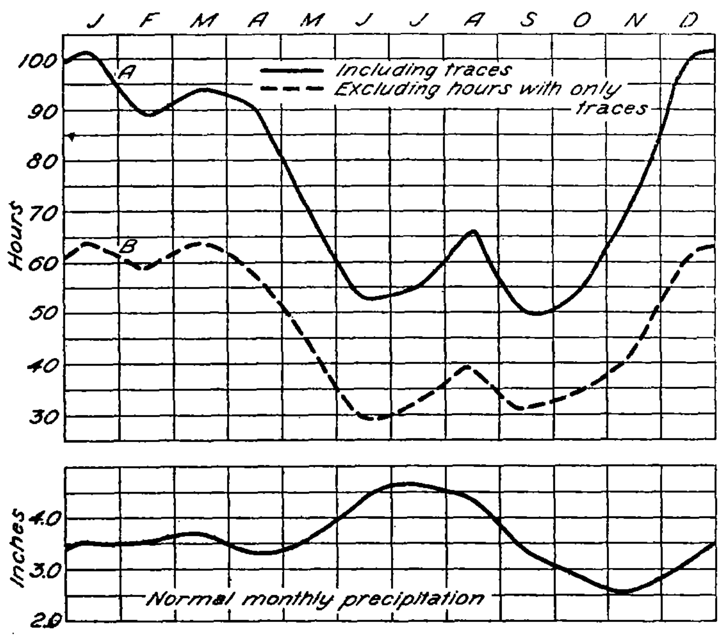

Figure 1.—Average total duration of precipitation, hours per month, Baltimore, Md., and normal monthly precipitation

Is it not just as interesting and important to know how much of the time rain falls as to know how much of the time the sun shines brightly? Is it not true that falling rain, or snow, or sleet, is of more concern to outdoor operations in general than is the presence or absence of bright sunshine? How does the number of rainfall hours at Baltimore compare with those at Boston, New York, New Orleans, Denver, Chicago, Cleveland, or any other station?

Fassig, in his "Climate of Baltimore," 1907, gives data on the duration of precipitation for each precipitation period or storm passage. For example, he found that the average duration per rain period, taking the year as a whole, is 8.2 hours. He counted the entire interval between the beginning and ending of precipitation of each storm, regardless of interruptions in the continuity of the fall. In this manner Fassig shows how long the average rainstorm or snowstorm lasts. Cox and Armington, in their book "Climate of Chicago," give similar data. These investigations—which are the only studies of the kind that have been published in the United States, so far as I know—and those described in the present paper are along somewhat similar lines, but are by no means the same.

At several Weather Bureau stations data on the frequency of precipitation have been compiled and published, but none of the works referred to covers the subject of the present paper, in which the purpose is to show just how much of the time precipitation occurs, on an average, per day, month, and year, and the distribution of precipitation hours through the day and the seasons.

To discover the facts, the hourly records of precipitation at Baltimore, Forms 1014, for a 10-year period, 1919–1927, were examined. The duration of precipitation for each hour was compiled and entered upon suitable forms. One form holds a month's record of precipitation duration data. These hourly precipitation duration data are exactly similar in arrangement to hourly sunshine data on Weather Brueau Forms 1014, daily local record. All beginnings and endings of precipitation were considered and all intervals between showers were eliminated. The totals for each day, in hours and tenths, were compiled. Then the monthly totals were computed.

In the first compilation all occurrences of precipitation, including periods with only traces, were counted and tabulated. Then a second examination of the records was made, in which all hours having only traces recorded were eliminated, and a total of the duration, excluding traces, was found. We thus have (1) the total duration of precipitation including periods with traces, and (2) the duration excluding periods with only traces and including only such precipitation as amounted to 0.01 inch or more within an hour. (Fig. 1.)

It is interesting to compare the two records. For example, it is seen that more than one-third of the duration of rainfall at Baltimore is for precipitation at the rate of only a trace an hour; for it is found that the average total precipitation hours for the year is 901 hours when traces are included and only 557 hours when traces are not counted.

It seems important to eliminate the traces—those periods of mere sprinkling or misting—when we consider the data in their economic bearing; for while sprinkling or misting often may be a drawback to outdoor operations, their effects are very slight as compared with those of a wetting rain. Therefore, the remainder of the discussion is based mostly upon compilations from which traces of rain were excluded.

From the hourly data for the 10-year period, 1918–1927, the total durations for each month and year were compiled, and from these the averages by months and the year. Excluding traces, the average precipitation hours at Baltimore, reduced to whole numbers, are as follows: January, 64 hours; February, 59; March, 63; April, 57; May, 44; June, 29; July, 32; August, 40; September, 31; October, 34; November, 42; December 60; for the year, 557.

The greatest monthly number of precipitation hours in the 10-year period was 114 hours, April, 1918; the least,

[1] Read before the American Meteorological Society meeting at New York, December, 1928.

1.8 hours, October, 1924. The greatest annual number of hours was 637, in 1920, and the least 502, in 1925.

It is thus seen that during the winter and early spring the average duration per month is nearly the same; that the duration decreases rapidly in the second half of April and in May, and reaches the lowest for the year in June; that it rises slightly in July, and rises considerably in August; that it falls in September to almost as low as in June; rises gradually in October, and rapidly in November and the first half of December.

Possibly, a more effective way of expressing the duration is found in giving the number of hours per day (on the average) that it rains in the different seasons, and we find that in January precipitation of some kind is occurring, on the average 2.1 hours per day; in February 2.1 hours per day; in March, 2.0; April, 1.9; May, 1.4; June, 1.0; July, 1.0; August, 1.3; September, 1.0; October, 1.1; November, 1.4; December, 2.0; for the year round, 1.5 hours per day.

Another way to put it is by the percentage method (Fig. 3.) In January, precipitation is occurring, on the average, 8.6 per cent of the time; in February, 8.7 per cent; March, 8.5; April, 8.0; May, 5.9; June, 4.1; July, 4.3; August, 5.3; September, 4.3; October, 4.6; November, 5.9; December, 8.1; for the year, 6.4.

Percentages afford the best comparison of one month with another, as the variations in the lengths of months are taken care of. In percentages, February is shown to be the rainiest period of the year, by a slight margin over January, which is the next rainiest; while June has a lower percentage of rainy hours than any other month, but with July and September almost as low. August has decidedly more rainy hours than July or September—a rather noticeable feature of the diagrams—which is probably due to tropical storms and other storms moving up the Atlantic coast, which sometimes cause lengthy periods of rain at Baltimore, and which, apparently, are more frequent in August than in July or September, this being the case, at least, in the 10-year records under consideration.

Another interesting investigation was the tabulations to show how the duration of precipitation is distributed through the 24 hours of the day, in the different months and seasons. For this purpose the averages for each hour of the day for the 10-year period were computed. (Table 1.) It was found that in the winter season the duration is greatest between about 5 a. m. and about 8 a. m., and least between about 5 p. m. and about 9 p. m. The highest actual average is for the hour 6 to 7 a. m., and the least actual average is for the hour 5 to 6 p. m. (Fig. 2.)

In the summer season the duration is greatest for the hour 8 to 9 p. m. and least for the hour 10 to 11 a. m. It was surprising to find that the greatest duration in summer was not in the middle of the afternoon or a little later, but comes as late at 8 to 9 p. m. However, the hours 4 to 6 p, m. do show the second greatest duration period and are distinctly marked as compared with the next preceding and next following hours. It may be that thunderstorms that occur late in the afternoon give a more persistent rainfall than those that occur in the warmest part of the day; but this I have not investigated.

The greatest average total duration of precipitation per month for any hour in the year is 3.4 hours (11 per cent), in January, between the hours of 5 a. m. and 6 a. m., and in December between the hours of 4 a. m. and 6 a. m. The least average total duration per month for any hour is 0.5 hour (1.6 per cent), for the 2-hour period, 10 a. m. to 12 noon, in July.

Winter and summer differ decidedly in precipitation duration characteristics, but spring and fall do not show very distinct characteristics in these data. Duration in early spring is very much like it is in winter, while in late spring it is very much like it is in early summer. In early fall it is much the same as in the summer, and in late fall it is pretty much the same as in winter.

On the other hand, there are two interesting similarities of winter and summer. (Fig. 2.) Both show an increase in precipitation duration during the hours 6 a. m. to about 8 a. m., and both show a decline in durations between the hours of about 8 a. m. and 10 a. m. and continue low until about noon, or a little later. The annual curve, of course, shows similar variations. It

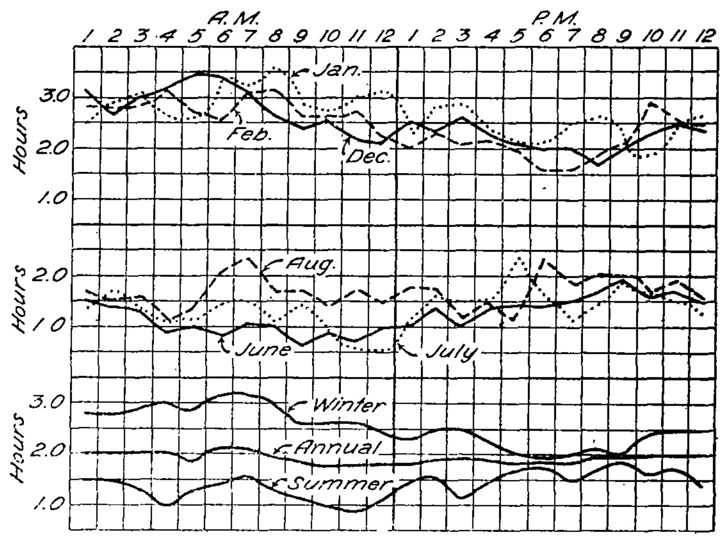

FIGURE 2.—Duration of precipitation; average total duration per month for each hour of the day, excluding traces, Baltimore, Md.

may therefore be said that rainfall duration is greatest between the hours of about 6 a. m. and about 8 a. m., and least between the hours of about 10 a. m. and about 12 noon, considering the year as a whole. These features may be explained by the normal temperature trend; that is, precipitation probably occurs more with falling temperature, or around the period of minimum temperature for the day, and occurs less with the rising temperature of the late forenoon.

The duration of precipitation in a climate such as we have in the eastern half of the United States is overestimated by most people. That was my opinion before making these studies. The facts brought out in this work convince me that the average person believes that rainy weather prevails much more of the time than the records indicate. And the average person probably underestimates the amount of sunshine, especially in the winter and spring seasons. I have therefore made diagrams to show comparisons between the number of rainy hours and the number of sunshiny hours at Baltimore. The diagram (fig. 3) shows the data in percentage of the time. The percentage method is preferable, because the proportions in the percentage diagram are accurate, while in the comparison by hours per day we must remember, and allow for, the fact that the sun works only half the day, on the

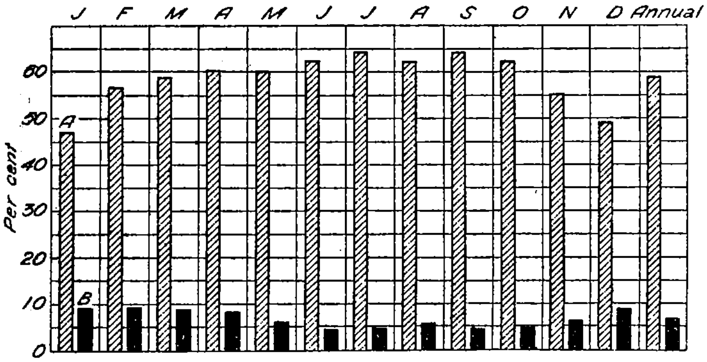

FIGURE 3.—Duration of sunshine and of precipitation, percentage of possible, Baltimore, Md. (A) Sunshine. (B) Precipitation

average, while rainfall is possible throughout the 24 hours. In a word, it is found that bright sunshine occurs nine times as much of the possible time as rainy weather occurs, taking the year round, at Baltimore; that is, the rainfall duration percentage of the possible for the year is 6.4 per cent, while the bright sunshine hours total 58.0 per cent of the possible.

TABLE 1.—*Total duration (hours) of precipitation, excluding hours with only traces, Baltimore, Md. (1919–1927)*

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1918	68.5	27.3	65.2	114.3	25.6	26.6	26.5	21.3	48.4	16.7	18.4	64.6	523.4
1919	65.8	57.7	70.2	38.9	66.8	22.5	57.6	35.2	14.4	67.2	65.5	70.7	632.5
1920	79.4	90.3	63.1	77.8	37.3	48.8	19.7	80.5	30.2	5.0	56.3	48.7	637.1
1921	46.5	53.0	48.4	48.9	73.3	13.9	29.3	29.6	14.2	23.9	82.3	47.9	511.2
1922	67.3	72.9	85.2	24.2	46.5	40.0	37.8	23.7	17.1	20.6	8.7	67.7	511.7
1923	67.7	59.0	71.1	60.2	25.0	17.7	29.5	33.5	32.3	30.3	41.5	76.6	544.4
1924	37.7	52.0	90.5	58.4	84.4	36.3	15.3	28.1	83.2	1.8	21.7	41.5	550.9
1925	93.6	26.7	51.6	50.8	15.6	18.6	35.2	29.4	11.5	76.2	46.3	46.4	501.9
1926	70.5	81.8	54.2	29.4	25.0	21.3	51.9	70.7	47.7	36.7	49.4	68.4	607.0
1927	42.4	69.2	29.5	71.1	42.5	47.8	20.5	45.0	11.6	67.0	32.7	72.5	551.8
Mean	63.9	59.0	62.9	57.4	44.2	29.4	32.3	39.7	31.1	34.5	42.3	60.5	557.2

TABLE 2.—*Average total duration (hours) of precipitation, excluding traces, Baltimore, Md. (1919–1927)*

	A. M.												P. M.											
	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Midnight
January	2.5	2.8	3.0	2.7	2.6	3.4	3.3	3.6	2.8	2.7	3.0	3.1	2.3	2.7	2.7	2.4	2.1	2.1	2.5	2.6	2.0	1.9	2.5	2.7
February	2.8	2.8	2.8	3.2	2.7	2.6	3.0	3.1	2.7	2.7	2.7	2.3	2.0	2.3	2.1	2.1	1.9	1.6	1.6	1.9	2.1	2.9	2.5	2.5
March	2.4	2.3	3.1	3.1	2.8	2.8	2.8	2.9	3.0	2.7	2.5	2.9	3.0	2.5	2.6	2.6	1.9	2.5	2.2	2.4	2.5	2.7	2.0	2.7
April	2.2	2.5	2.4	2.1	1.9	1.9	2.4	2.6	2.4	2.5	2.5	1.8	1.8	2.3	2.5	2.6	2.4	2.2	2.3	2.8	2.8	2.8	2.9	2.9
May	1.4	1.7	1.7	2.2	2.0	2.2	1.8	1.6	1.4	1.3	1.4	1.7	1.5	1.3	2.0	1.9	2.1	2.0	2.4	2.5	1.6	2.3	2.2	2.1
June	1.5	1.3	1.3	0.8	1.0	0.8	1.0	1.0	0.6	0.8	0.7	1.0	1.0	1.4	1.0	1.3	1.4	1.4	1.5	1.7	2.0	1.6	1.7	1.5
July	1.3	1.7	1.3	1.1	1.1	1.4	1.5	1.1	1.4	0.8	0.5	0.5	1.1	1.6	1.5	1.5	2.4	1.7	1.2	1.4	1.9	1.7	1.5	1.2
August	1.6	1.5	1.5	1.1	1.7	2.0	2.3	1.7	1.7	1.4	1.6	1.5	1.7	1.7	1.1	1.4	1.2	2.3	1.9	2.0	2.0	1.6	1.8	1.5
September	1.4	1.0	1.2	1.0	1.2	1.3	1.5	1.4	1.0	1.2	1.2	1.0	1.1	1.2	1.2	1.2	1.2	1.3	1.5	1.9	1.5	1.4	1.5	1.3
October	1.1	1.1	0.6	1.2	1.2	1.2	1.4	1.5	1.6	1.9	1.6	2.2	2.0	2.1	1.7	1.4	1.4	1.5	1.5	1.3	1.4	1.4	1.0	1.2
November	2.1	2.3	2.1	2.1	1.6	1.8	1.5	1.2	1.8	1.5	1.6	1.7	2.1	1.6	1.9	2.2	1.8	1.7	1.7	1.7	1.6	1.7	1.5	1.6
December	3.2	2.7	3.0	3.2	3.4	3.4	3.2	2.7	2.4	2.5	2.2	2.1	2.5	2.3	2.6	2.3	2.1	2.0	2.0	1.7	2.0	2.3	2.5	2.4
Mean	2.0	2.0	2.0	2.0	1.9	2.1	2.1	2.0	1.9	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.8	1.9	1.9	2.0	2.0	2.0	2.0	2.0

A SIMPLE METHOD OF MEASURING THE DIFFUSED RADIATION OF THE SKY ACCORDING TO ZONES

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The solar radiation diffused by the atmosphere is generally measured for the whole vaulted sky. Meanwhile the study of this radiation, not as total for the whole vault, but with regard to the several zones, presents a great interest, as much theoretical as practical.

I should like to give in this short note a description of a simple method applied by me for the above purpose. I made use of the well-known pyranometer of A. Ångström, a splendid instrument, giving, if shaded from the sun by a small screen, the intensity of solar radiation diffused by the atmosphere.

The complete installation is shown in Figure 1; the principle of its action is the following: The pyranometer is placed on the line of the axis of the cylinder B, the latter being subject ad libitum to being raised or lowered, and fixed in position by means of the screw H. If the upper rim of the cylinder be placed at the level of the plane within which are disposed the receiving plates of the pyranometer, the apparatus will be subjected to the effect of radiation from the whole vault of the sky. As the cylinder B is shifted higher and higher the vault is more and more covered, beginning with parts adjacent to the horizon, so that they will have no effect on the pyranometer.

The dimensions of the cylinder B being known, it is easy to compute beforehand the height at which the cylinder B must be placed so as to cover the vault to 10°, 20°, 30°, etc., from the horizon.

The installation constructed by me allows a covering of the sky by means of shifting the cylinder up to 60°. For a further screening of the sky a higher cylinder might be used; but as this is inconvenient I adopted the following proceeding: The cylinder B being adjusted at the height to screen the sky up to 60°, it is partly closed by the cover C, which has a round opening and screens the sky up to 70° from the horizon. If the cover D be substituted for the cover C, the sky is shaded up to 80°.

Thus the above adjustment permits us to measure the radiation of the whole vault as well as its several parts in the form of circular zones of any desired width. The cylinder B as well as the covers C and D have been lined with black velvet in order to avoid all possible reflection.

The ingenious arrangement of the receiving surfaces of A. Ångström's pyranometer eliminates any possibility